Energy Policy 38 (2010) 4945–4954

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Renewable energy in South Africa: Potentials, barriers and options for support

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A R T I C L E   I N F O

Article history:
Received 22 December 2009
Accepted 30 March 2010
Available online 14 May 2010

Keywords:
Renewable energy
Low-carbon development
South Africa

A B S T R A C T

The challenge of transforming entire economies is enormous; even more so if a country is as fossil fuel based and emission intensive as South Africa. However, in an increasingly carbon constrained world and already now facing climate change impacts South Africa has to reduce greenhouse gas emissions intensity soon and decidedly. The South African electricity sector is a vital part of the economy and at the same time contributes most to the emissions problem. First steps have been taken by the South African government to enhance energy efficiency and promote renewable energy, however, they fail to show large-scale effects. This paper seeks to identify the relevant barriers to renewable energy investments and, based on experience from other countries, provide policy recommendations.

The major barrier identified in the paper is based on the economics of renewable energy technologies, i.e. their cost and risk structures, two main factors in investment planning. As a solution, the South African government introduced several renewable energy support measures, such as a feed-in tariff. The paper discusses the potential and possible shortcomings of this and other existing support schemes and identifies complementing measures on a national scale.

1. The challenge

Climate change is one of this century's most serious problems. The Fourth Assessment Report of the Intergovernmental Panel on Climate change (IPCC) points to human activity as one of the major causes of global warming. Business as usual may lead to a disastrous transformation of the planet, and recent scientific findings emphasize the growing urgency of reducing greenhouse gas emissions (Meinshausen et al., 2009).

The parties to the climate negotiation process under the UN Framework Convention on Climate change (UNFCCC) are struggling to find an agreement that may prevent dangerous climate change. Yet the emission reduction proposals on the negotiating table are not strong enough to ensure that global warming stays at a manageable level. Rapid and substantial emission reductions are vital, and they require a global structural change, mainly in the energy sector.

Most past emissions have stemmed from the energy sector in high-income countries. Less than 25 per cent of cumulated emissions have been caused by developing countries (Stern, 2007, 175).[1] However, in recent years, the developing countries' share of global emissions has been rising. In 2000 they already accounted for about 55 per cent of yearly global greenhouse gas emissions (WRI, 2009). High economic growth in some of these countries has led to quickly rising energy demand. As this demand has been satisfied mostly by fossil fuels, emissions have also been rising. Estimates predict a continuation of this trend unless the energy sector, and especially electricity generation, is converted to using low-carbon technology. In a business-as-usual scenario put forward by the International Energy Agency (IEA) global energy-related emissions will rise by 45 per cent between 2006

Abbreviations: ANC, African National Congress; BMU, Bundesministerium für Umwelt Naturschutz und Reaktorsicherheit (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety); CAIT, climate analysis indicators tool; CDM, Clean Development Mechanism; CSP, concentrating solar power; DEAT, South African Department of Environmental Affairs and Tourism; DLR, Deutsches Zentrum für Luft- und Raumfahrt; DME, South African Department of Minerals and Energy; DNA, Designated National Authority; GDP, gross domestic product; HFC, hydrofluorocarbon; IEA, International Energy Agency; IPPs, independent power producers; IPCC, Intergovernmental Panel on Climate Change; LTMS, Long-Term Mitigation Scenario; MW, megawatt; Nersa, National Energy Regulator of South Africa; PV, solar photovoltaic; REFIT, Renewable Energy Feed-In Tariff; SABS, South African Bureau of Standards; UNDP, United Nations Development Programme; UNEP, United Nations Environment Programme; UNFCCC, United Nations Framework Convention on Climate Change; USD, US dollar; US EIA, U S Energy Information Administration; WRI, World Resources Institute; ZAR, South African rand

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[1] Stern (2007) defines the group of developing countries as equivalent to Non-Annex I parties to the Kyoto Protocol. To achieve comparability, this definition shall be kept in the following.

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doi:10.1016/j.enpol.2010.03.077

and 2030 (IEA, 2008b, 11). Almost all of this increase (97 per cent) is expected to occur in non-OECD countries, mostly due to greater use of coal.

Even though the contribution of South Africa to total global emissions is still moderate (1.1 per cent in 2005), its per capita emission rate of 9 tonnes CO_2e per person in 2005 was above the global average of 5.8 tonnes and more than six times higher than the sub-Saharan average of 1.4 tonnes (WRI, 2009).[2]

At the same time, the lack of access to energy and the consequent restrictions to development remain major challenges. In 2004, 28 per cent of South African households were not electrified. The government aims to achieve universal access by 2012 (Eskom s.a.). However, in the past enhanced energy access has always been linked to rising emissions. The challenge therefore lies in decoupling energy and greenhouse gas emissions so that more widespread energy use and decreasing emissions can be achieved simultaneously. The deployment of low-carbon technologies[3] on a massive scale must be part of the solution.

Part of the funding for these massive investments may come from public sources. However, as public resources are scarce they must be used wisely to leverage additional private funding. Furthermore, they must be accompanied by appropriate policy frameworks to create markets for low-carbon technologies.

This paper seeks to analyse South Africa's domestic options for a low-carbon development path by examining the prospects for renewable energy markets. It is arranged as follows. Section 2 discusses the impact of climate change on South Africa and thus its motivation to join in the global effort to reduce greenhouse gas emissions. Section 3 lays the foundations for the analysis by illustrating the structure and sources of South African emissions. Section 4 focuses on electricity generation as the sector accounting for the largest share of total CO_2 emissions. Section 5 explores and evaluates measures to reduce emissions in the electricity sector through the promotion of private investment in renewable energy. A discussion of the need for further action and policy recommendations in Section 6 complete the analysis.

2. South Africa in the face of climate change

Africa is regarded by the United Nations as one of the continents most vulnerable to the impacts of climate change as a consequence of its high dependency on agriculture, the water stress from which it already suffers and its weak adaptive capacity (IPCC, 2007, 435). The likely impacts are numerous, ranging from changes in water availability and extreme weather events to sea level rise and adverse health impacts.

However, the impacts of climate change differ in the various African regions. In South Africa, water supply is a particularly vulnerable area with respect to climate change. Even without climate change, South Africa might utilise most of its surface water resources within a few decades (DEAT, 2005). Climate change is likely to intensify water scarcity, increase demand for water and lead to deterioration of water quality. Desertification may thus be exacerbated. This is already a widespread problem in the country, much of South Africa being arid and subject to droughts and floods. Agricultural output, which needs to increase to meet the needs of a growing population, can be expected to decline unless corrective measures are taken.

According to World Bank estimates, agricultural yield losses of up to 20 per cent can be expected in South Africa (World Bank, 2009, p. 145). As a consequence of the expected decrease in river flows, the areas suited for the country's fauna and flora may shrink to about half of their current size, resulting in huge losses of biodiversity. This may in turn affect tourism, which contributes as much as 10 per cent of South African GDP, the potential economic loss thus being considerable (Turpie et al., 2002, iii). Climate change can further be expected to have an adverse effect on health in South Africa. The higher temperatures may cause an increase in the occurrence of skin rashes, dehydration and death due to heat strokes. Moreover, temperature rises and changes in rainfall patterns will enlarge the breeding grounds for diseases such as malaria and bilharzia, leading to a higher proportion of deaths, higher treatment costs and a greater loss of earnings (DEAT, 2005).

In addition, the adaptive capacity of large sections of the South African population is low. According to the United Nations Development Programme, 43 per cent of the population still live on less than USD 2 per day (UNDP, 2008, 34). The majority of the poor live in rural areas and rely on agricultural incomes (Mbuli, 2008, 4), which are sensitive to changes in weather patterns likely to occur as a result of global warming. The low saving capacity of poor households and the frequent lack of access to financial services mean limited financial reserves for use in the event of a bad harvest. If households are forced to sell income-earning assets to survive a bad year, they can fall into extreme poverty.

3. South Africa's contribution to climate change

South Africa is already being affected by global climate change, and the impacts will intensify in the coming decades. However, it is also a contributor to global greenhouse gas emissions. In 2005, it was responsible for about 1.1 per cent of global emissions and about 40 per cent of emissions in sub-Saharan Africa (WRI, 2009). At an average of 9 tonnes CO_2e per person in 2005, the per capita emission rate almost equalled the average per capita emissions of 10.7 tonnes in the European Union. The validity of average values is, however, limited. As in many developing countries, the distribution of available income and thus household expenditures is highly uneven in South Africa (see Fig. 1). It is likely that expenditures on energy and thus emissions follow a similar distribution pattern.

As incomes rise and the South African government continues its attempts to provide universal access to electricity, emissions intensity is expected to increase, at least if the current carbon intensity of electricity production is maintained. At about 850 g CO_2/kWh, the South African average is nearly twice as high as in the industrialized countries. CO_2 consequently accounts for the largest proportion of total greenhouse gas emissions in the country (about 80 per cent), and it stems mainly from electricity production (WRI, 2009). Reasons for this high emissions intensity are discussed in the analysis of the South African electricity sector in the following section.

4. The electricity sector

4.1. Structure of the South African electricity sector

The sector is dominated by Eskom, a state-owned enterprise. Eskom not only produces almost all of South African electricity (95 per cent), but also owns and operates the national transmission system. Only about 2 per cent of South African electricity is produced by private companies.

[2] Including emissions of CO_2, CH_4, N_2O, PFCs, HFCs and SF6. 2005 data on emissions from land-use change and forestry are not yet available.

[3] As this paper focuses on renewable energy, the use of the term "low-carbon technologies" seems appropriate. However, the deployment of technologies that reduce the emission of greenhouse gases other than CO_2 is also important.

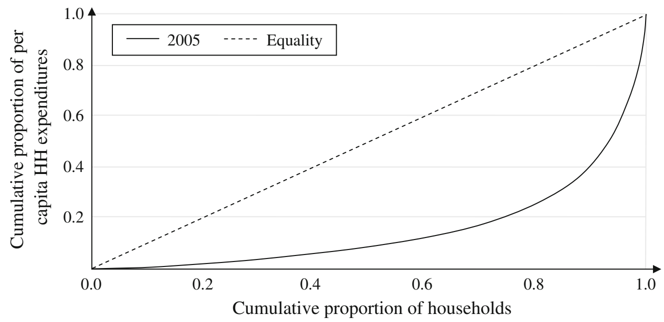

Fig. 1. Uneven distribution of household expenditures—Lorenz curve for South Africa, 2005.
Source: Adapted from Bhorat and van der Westhuizen (2008, 13).

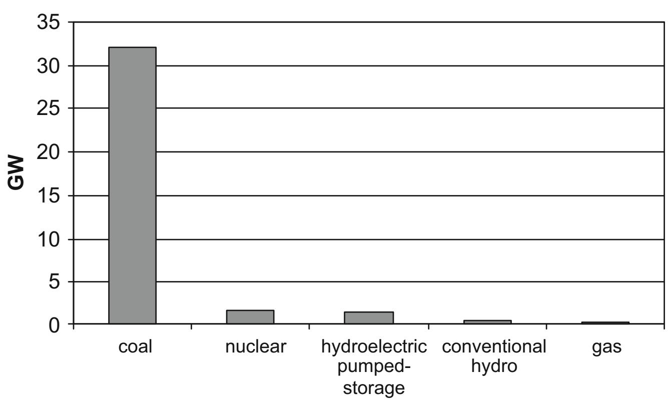

Fig. 2. Energy mix in South Africa.
Source: US EIA (2008).

The primary energy source used in electricity production is coal (86 per cent), followed by nuclear energy (5 per cent) and various other sources, including renewable energies such as hydro power (see Fig. 2). The coal used is easily accessible and of poor quality, resulting in a low input cost. At nearly 50 billion tonnes, South Africa has the world's sixth largest recoverable coal reserves. It will not therefore be due to a lack of coal that an energy shift takes place (US EIA, 2008).

Eskom is operating at nearly full capacity: peak demand is currently about 36 GW, matched by an installed capacity of nearly 40 GW, giving a narrow reserve margin of about 10 per cent (DME, 2008). This tense situation resulted in South Africa experiencing serious power shortages in early 2008, their economic impact estimated at between USD 253 and 282 million (US EIA, 2008).

The shortages were caused by rising demand and inadequate investment in additional supply. Until the mid-1990s, Eskom had excess supply capacity. However, in 1994 only 36 per cent of South African households had access to electricity (Eskom s.a.). In the course of mass electrification programmes, this situation has changed. In 2004, 72 per cent of households were electrified, and the government wants to achieve universal access by 2012. In addition, stable economic growth and industrialization have led to rising electricity consumption. In the future, demand for electricity is expected to increase by 4 per cent per year, leading to doubling of total demand and so an additional requirement of 40 GW by 2025.

To meet this challenge, the Department of Minerals and Energy and Eskom jointly released a policy document entitled "National response to South Africa's electricity shortage" in 2008. The plan includes such supply-side interventions as a 19,000 MW generation capacity expansion programme involving two new coal-fired power stations, the return to service of three stations mothballed in the 1990s and the exploration of co-generation and renewable energy options (DME, 2008, 9). This strategy will obviously aggravate the emissions problem. On the demand side, the aim of the "Power Conservation Programme" is to reduce demand in the short term by means of power quota allocations combined with penalties and positive incentives. In the medium term, Eskom seeks to encourage electricity savings inter alia through programmes promoting the increased installation of solar water heaters and use of energy-efficient light bulbs. These programmes are, however, making slow progress. One reason for this is a lack of the skilled personnel needed for the testing and installation of solar water heaters. Another reason may lie in the programme's lack of funding, which is related to Eskom's record loss of ZAR 9.7 billion in 2008 and the high capital requirements of the new build programme.

In the longer term, Eskom seeks to introduce further demand side management measures which are expected to reduce demand by about 3000 MW by 2012 and a further 5000 MW by 2025. The core measure is smart metering, where consumers' electricity demand can be metered remotely and in real-time rather than manually and at intervals (DME, 2008, 15). Thereby, the accuracy of reading and hence billing can be improved and consumers can be provided with information about the patterns of their electricity use. This may help to smooth peak demand. Smart metering also facilitates more rigorous measures such as the remote disconnection of consumers whose demand exceeds a threshold level. However, smart metering requires the retrofitting of existing meters with wireless technologies. This is a costly process, and in the light of Eskom's current lack of funding a rapid implementation is unlikely.

The adjustment of the power tariff regime to reflect the actual cost of electricity provision will help to ease Eskom's tense financial situation. It will also create incentives for energy saving. In 2008, Eskom applied for a 60 per cent electricity tariff increase, and the National Energy Regulator of South Africa (Nersa) eventually allowed a 27.5 per cent rise, approving a further 31.3 per cent rise in 2009. In spite of this increase, the price of electricity in South Africa is among the lowest in the world.

The South African electricity sector therefore faces three problems. The first is electricity undersupply, resulting in a narrow reserve margin and power shortages. Given a projected doubling in demand within the next 15 years, the pressure to increase electricity supply and/or reduce demand is immense. Second, Eskom estimates it will need ZAR 300 billion over the next decade for the extension of power infrastructure. At the same time, Eskom is dramatically underfunded. The third problematic aspect is the high emission intensity of the South African economy, especially the electricity sector, and the resulting environmental damage.

The promotion of renewable energy technologies can provide a solution to the electricity supply and emission intensity aspects of the South African energy challenge. However, in spite of a high resource potential, there has so far been little progress in the deployment of renewables. The obstacles to the large-scale dissemination of renewable energy in South Africa are numerous, but not impossible to overcome. The following section discusses the central barriers.

4.2. Barriers to renewable energy

While there are some natural barriers, such as the limits to biomass use, and specific technology needs, such as waterless

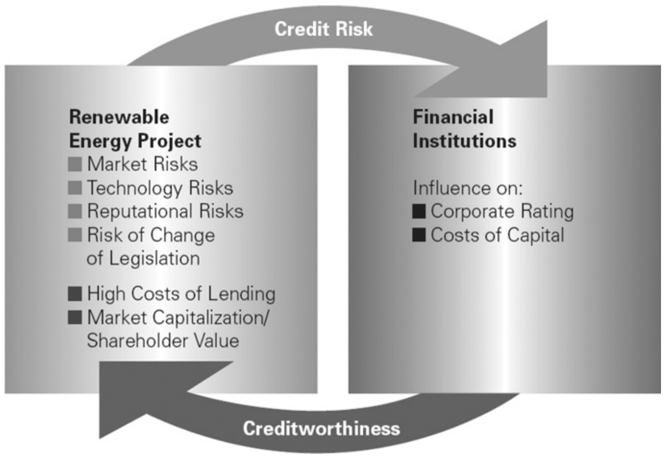

Fig. 3. Renewable energy projects, lending cycle.
Source: Allianz Group and WWF (2005, 46).

cooling systems owing to the scarcity of water, the main barriers are to be found in the South African energy innovation system and in the economics of renewable energy technologies.

The South African innovation system is characterized by a high path dependency. Having its roots in the apartheid period, when independence from external energy supplies was a political necessity, energy research has centred on fossil fuel technologies. As coal is an abundant source of energy in South Africa, both electricity and fuel are produced from coal. The two main energy providers, Eskom (electricity) and Sasol (fuel), are responsible for the bulk of investment in energy research and development. At the same time, they are almost monopsonistic employers of university graduates in the relevant fields. These patterns have led to an extreme bias in innovative capacity towards fossil fuel innovation. Renewable energy technologies, on the other hand, lack the capacity basis at all levels of education. As monopolistic energy providers, both Eskom and Sasol wield considerable power. They use their influence to protect those of the energy market's features suited to their core competencies. Fostering a favourable environment for renewable energy providers is certainly not a part of this strategy.

However, the path dependency of the South African energy innovation system is not the only barrier. Renewable energy technologies also entail certain economic features that act as barriers to their deployment. These can be divided into risk and cost factors. Fig. 3 depicts the typical risk assessment and lending cycle of renewable energy projects.

Typically, the market for renewable energy technologies is quite young. Its lack of maturity leads to higher volatility and thus to greater risk. If these technologies are politically supported by schemes such as a feed-in tariff, as is the case in South Africa, it is uncertain whether a change of legislation will alter the economics of a given project. This adds to the market risk, as feed-in tariffs are an instrument of market creation. For example, the alteration of the Spanish feed-in tariff in 2008 led to a significant fall in solar technology market growth rates. As most renewable energy technologies are still in their infancy, they entail an additional technology risk. There are only a few concentrating solar power facilities in operation worldwide. The challenges this technology would face under South African conditions are still unknown. The enterprise making the first move, only to see its project fail, may face not only economic but also reputational risks. The financial institutions will factor all these risks into their credit conditions, which will raise the cost of lending. In addition, a lack of competition among South African financial institutions may have led to reluctance to explore new fields of lending activity in the past. As there is consequently a lack of experience with renewable energy projects, it is difficult for project developers to obtain funding on the private capital market.

In addition to the higher risk they entail, the competitive cost of renewable energy technologies is a very significant barrier in South Africa. The average price of electricity was ZAR 0.198 per kWh in 2007/2008, but since the increases in 2008 and 2009 it has been ZAR 0.3314 per kWh (Nersa, 2008a, 1). This price is approximately equivalent to EUR 0.03 per kWh, compared to average European prices for households in 2008 being around EUR 0.12 per kWh (European Commission, 2009). The cost of producing electricity from wind, one of the lowest cost renewable energy technologies, is about EUR 0.05 per kWh (IEA, 2008a, 3). This makes wind energy almost competitive with conventional energy in Europe, where conditions are favourable and fossil fuels are comparatively expensive. However, this is not the case in South Africa. Here, the consumer price of about EUR 0.03 per kWh is not sufficient to make wind energy commercially attractive, especially as South Africa does not have wind speeds comparable with sites in northern Europe.

The renewable resource with the greatest potential in South Africa is solar energy. There are two main technologies for producing electricity from solar radiation: concentrating solar power (CSP), also known as solar thermal energy, and solar photovoltaics (PV). CSP technology uses mirrors to concentrate the thermal energy of the sun and heat a transfer fluid. The heat energy is then used to produce steam, with which electricity is generated in conventional turbines. Photovoltaic panels normally use silicon to convert the solar radiation directly into electricity. Fig. 4 shows South Africa's solar energy potential as the annual direct and diffuse solar radiation received on a level surface.

The total area of high radiation in South Africa amounts to approximately 194,000 km^2, including the Northern Cape, one of the best solar resource areas in the world (Eskom, 2002). If the electricity production per square kilometre of mirror surface in a solar thermal power station is 30.2 MW and only 1 per cent of the area of high radiation is available for solar power generation, then generation potential is already about 64 GW (du Marchie van Voorthuysen, 2006, 6; Eskom, 2002). A mere 1.25 per cent of the

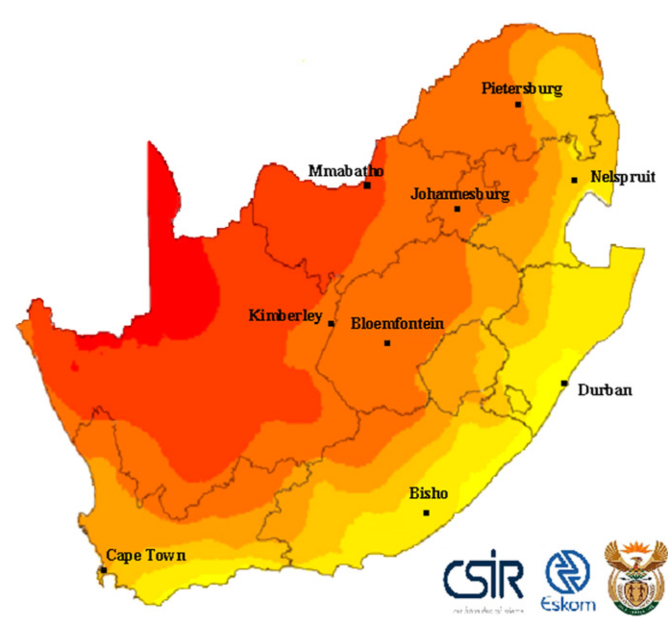

Fig. 4. Annual Solar Radiation South Africa.
Source: CSIR et al., s.a..

area of high radiation could thus meet projected South African electricity demand in 2025 (80 GW). This would, however, require large investments in transmission lines from the areas of high radiation to the main electricity consumer centres. The South African national energy regulator Nersa can direct the utilities to build these transmission lines, but as financial resources are scarce, there must be a thorough assessment as to where new lines are necessary and reasonable.

The current levelized cost of producing electricity from CSP plants is about EUR 0.13 per kWh in desert climates (DLR, 2005, 131). This comparatively high cost is due to the high initial investments in solar-thermal power stations. Nonetheless, CSP is the cheapest option for producing electricity from solar energy. It is suitable for large-scale plants and provides base load, as the heat produced can be stored more easily and cheaply than, for example, electricity from solar photovoltaic systems. However, CSP technology is still at an early stage of commercialization. The cost reduction potential has not yet been fully explored: the German Aerospace Centre (Deutsches Zentrum für Luft- und Raumfahrt) estimates a cost reduction down to EUR 0.05 per kWh at a global total installed capacity of 40 GW achieved between 2020 and 2025 (DLR, 2005, 10).

It thus becomes clear why renewable energy has not yet been exploited on a large scale in South Africa. None of the technologies can compete with coal-fired power stations generating electricity at EUR 0.03 per kWh.

Besides the abundant coal reserves, there is a second reason for the low price of electricity. Most South African power stations were built in the 1970s and 1980s, when exchange rates were favourable. In the meantime, they have been fully depreciated, and coal input is one of the largest cost factors. While this is now an obstacle to renewable energy, it may be a supportive factor in the future. Investments in new power capacity must not be compared to today's electricity production cost, but to the cost of alternative investments. Even the lowest cost options for additional capacity will require new capital input. The price of electricity will consequently rise in the future. Eskom's applications for higher tariffs in 2008 and 2009 to finance investment in new power stations document this trend. Over the next three years, Nersa projects annual tariff increases of 20–25 per cent (Nersa, 2008a, 2). However, the higher prices are already attracting public opposition since they are perceived as a threat to the goals of economic growth and poverty reduction. The political success of South Africa's African National Congress (ANC) party is closely linked to and dependent on success in reducing poverty. Given the power shortages and the underfunding of Eskom, it is doubtful that there will be enough funds available or the political will to invest public money in comparatively expensive and risky renewable energy technologies. It is therefore vital to promote private-sector participation.

5. Promoting private-sector involvement in renewable energy

While rising electricity prices will improve the competitive position of renewable energy technologies in the future, these technologies will still need considerable support if they are to be deployed on a commercial, large-scale basis. This support is needed as soon as possible, since investment cycles are comparatively long in the energy sector. Investments in fossil-fuel-powered stations undertaken today lock these technologies in for decades to come. The South African government has acknowledged this and consequently taken measures to support private investment in renewable energy and other clean technologies. In some of these measures, it has emulated successful examples in other countries.

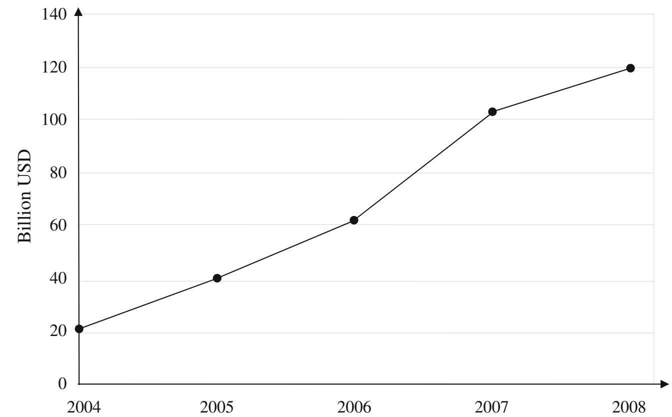

Fig. 5. Global investments in renewable energy (2004–2008).
Source: Renewable Energy Policy Network for the 21st Century REN21 (2009).

5.1. Renewable energy support schemes worldwide: an overview

By 2009, at least 73 countries had renewable energy policy targets, with no fewer than 64 having specific support schemes in place. As Fig. 5 shows, the enhanced policy actions and the concerns about energy security and climate change issues are reflected in private investments.

The most common and probably most effective policy instruments used in support of renewable energy technologies are feed-in tariffs (Mendonça, 2007, 8). First applied successfully in Germany, the scheme has spread to more than 40 countries. The idea behind a feed-in tariff is to guarantee producers fixed tariffs for power from renewable energy sources over a certain period of time, in most schemes 10–20 years. This creates a basis for long-term investment planning, since revenues are known and guaranteed in advance. The tariffs are usually differentiated according to the renewable energy technology supported. They exceed the normal electricity price paid by consumers and ideally enable the investor to cover his costs and earn a reasonable return on his investment. The additional costs due to the higher tariffs are passed on to all power consumers in the form of a premium per kilowatt hour. In some schemes, tariffs are adjusted over time to prevent consumers from paying unnecessarily high prices and to allow for technology learning curves. However, these adjustments must be predictable if investment certainty is to be maintained.

Renewable energy technologies are also supported by quota models in some countries, notably the UK and Sweden (Mendonça, 2007, 9). In the quota model it is not the tariff that is fixed but the quantity of power that must be generated from renewable energy sources or the share of renewables in total capacity. The market then determines the price. However, quota systems appear to be less effective than feed-in tariffs. They do not allow for price differentiation for different technologies, as there is only one price for power produced from renewable sources. This promotes least-cost technologies and project sites and so brings costs down quickly, but it also inhibits the development and commercialization of such earlier-stage technologies as offshore wind and solar thermal energy. Furthermore, as the price is determined by the market, there is no certainty for investors about future prices. If there are few actors in the market, price fluctuations may be high. This results in additional risk, which is priced at a premium by the private sector and acts as an unnecessary obstacle to investment.

Other support schemes include tax incentives or subsidies for particular technologies, such as solar photovoltaics. In addition to raising the revenues from renewable energies, the cost of competing fossil fuel technologies needs to be increased if renewables are to become more competitive. This can be done through carbon taxes, cap-and-trade systems or other ways of internalizing the external costs caused by fossil fuel technologies. Furthermore, the implicit or explicit subsidization of fossil fuels must be reviewed, even if this is strongly opposed by both powerful interest groups and the general public.

5.2. The South African status quo

5.2.1. Renewable energy White Paper

In 2003 the South African Department of Minerals and Energy (DME) published a White Paper on renewable energy. This document supplements the DME White Paper on Energy Policy of 1998 and presents the South African government's vision, policy principles, strategic goals and objectives in the promotion and introduction of renewable energy (DME, 2003, vii).

In the document the DME sets a target of an annual 10,000 GWh renewable energy contribution to final energy consumption by 2013 (DME, 2003, vii). As the principal energy sources, the White Paper refers to biomass, wind, solar and small-scale hydro. It focuses on larger and economically viable projects rather than small-scale electrification programmes, even though electrification is seen as an especially pressing issue in rural areas. The government is also committed to developing a Strategy on Renewable Energy, which will "translate the goals, objectives and deliverables set out herein into a practical implementation plan" (DME, 2003, xiii). This overarching strategy has yet to be drafted, however.

Given Eskom's competitive advantage and core competencies in fossil fuel technologies, independent power producers (IPPs) are considered more capable of contributing to South Africa's renewable energy capacity. To achieve the 10,000 GWh renewable energy target, the government is thus committed to strengthening competition in the electricity market. At present IPPs do not face a level playing field as they have to sell their electricity to Eskom as the monopsonistic buyer. Being a competitor of IPPs and the single buyer of their electricity at the same time, Eskom clearly faces a conflict of interest. In his State of the Nation Address in early 2010 South African president Jacob Zuma therefore announced an Independent System Operator to be established separately from Eskom. Once operational, this institution will be the contractor of IPPs. This is an important step to limit Eskom's market power and create an enabling environment for renewable energy power producers.

The Renewable Energy White Paper specifies a policy review process after five years to see whether the targets, objectives and deliverables are being met. This process started in 2008, but has made little progress to date. The revised White Paper is expected to be published in early 2011.

5.2.2. Long-Term Mitigation Scenarios

In 2007, the South African government produced two Long-Term Mitigation Scenarios (LTMS) (DEAT, 2007). They show possible emission pathways from 2003 to 2050. In the first scenario, "Growth without Constraints", policy follows business as usual. Economic growth is limited neither by resource constraints nor by negative feedbacks of a changing climate. Emissions are projected to quadruple between 2003 and 2050. Seeing that the international community is growing increasingly carbon conscious and "Growth without Constraints" would contribute to catastrophic impacts, the South African government dismisses this scenario as being neither robust nor plausible (DEAT, 2007, 12). The other scenario, "Required by Science", is a mitigation scenario that aims at reducing South African emissions by 30–40 per cent between 2003 and 2050. For this scenario, four options with increasing levels of ambition are identified: Start Now, Scale Up, Use the Market and Reach for the Goal (see Fig. 6).

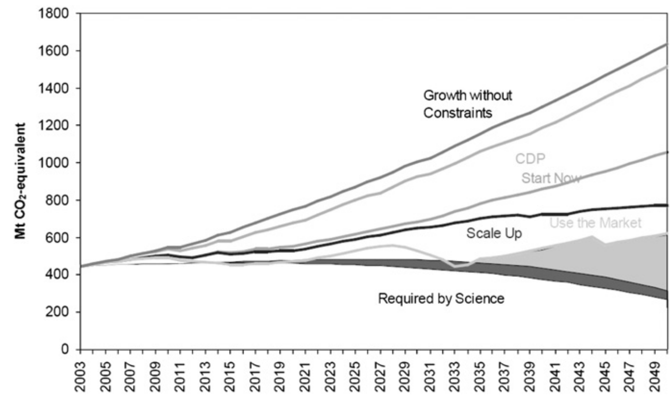

Fig. 6. South African mitigation options 2003–2050, Long-Term Mitigation Scenarios. CDP depicts the development of emissions under current development plans. *Source*: DEAT (2007, 24).

"Start Now" focuses on mitigations actions with positive upfront investments but net negative costs. Energy efficiency measures are a classic example. "Scale Up" adds net positive cost actions such as investments in carbon capture and storage and aims at a zero carbon electricity sector by 2050. "Use the Market" introduces additional economic instruments such as a carbon tax. The last and most ambitious option, "Reach for the Goal", depicted as a grey wedge in Fig. 6, combines the mitigation efforts of the other three options and adds the use of yet unknown technologies and behavioural change. Possibilities for change are identified across almost all spheres of life, such as transport modes (e.g. shifting to public transport and reducing distances between home and work), urban planning (e.g. greening of towns and establishing fresh air corridors to reduce cooling needs) and population growth.

Only the "Reach for the Goal" option achieves the envisaged emission reductions of 30–40 per cent from the 2003 level. However, as it involves new technologies and attempts to steer behaviour, it entails a high level of uncertainty.

The Long-Term Mitigation Scenario (LTMS) energy model assumes a renewable electricity share of 15 per cent in 2020 and 27 per cent by 2030 (Hughes et al., 2007, 37). However, it is unclear if and how this share needed for the LTMS will be reached, as South Africa has made little progress towards achieving its 10,000 GWh target in the first half of the period (DME RED, 2009, 12). To date, only about 3 per cent (296 GWh) of the target has been installed (DME RED, 2009, 13).

Although little has actually been achieved so far and no overarching renewable energy strategy has been established, a number of policy actions expected to augment renewable energy deployment in the coming years are planned or have already been implemented. They are discussed in the following.

5.2.3. Renewable Energy Feed-In Tariff (REFIT)

The policy instrument most recently introduced in South Africa in support of renewable energy technologies is the Renewable Energy Feed-In Tariff (REFIT).

When the scheme first emerged, the national energy regulator Nersa planned for rather low tariff rates subject to annual degression (Table 1). With rates guaranteed for fifteen years, the time span for investment planning was short compared to the capital life spans of renewable energy investments of 25–30 years assumed in Nersa's initial calculation (Energy for Sustainable Development Ltd., Palmer Development Group, 2008, 7–13).

Table 1
Tariff schedule initial REFIT 2008–2013 in ZAR c/kWh (EUR c/kWh).[a]
Source: Nersa (2008b, 8)

	2008	2009	2010	2011	2012	2013
Wind	65.48 (6.6)	63.87 (6.4)	62.31 (6.2)	60.78 (6.1)	59.29 (5.9)	57.84 (5.8)
Hydro	73.76 (7.4)	73.34 (7.3)	72.92 (7.3)	72.51 (7.3)	72.10 (7.2)	71.69 (7.2)
Landfill gas	43.21 (4.3)	42.71 (4.3)	42.21 (4.2)	41.72 (4.2)	41.23 (4.1)	40.75 (4.1)
Concentrating solar power	60.64 (6.1)	60.03 (6.0)	59.43 (5.9)	58.84 (5.9)	58.25 (5.8)	57.67 (5.8)

[a] Exchange rate used is ZAR 1 = EUR 0.10 (23 March 2010).

Table 2
Revised REFIT rates.
Source: Nersa (2009a, 28).

	ZAR c/kWh (EUR c/kWh)
Wind	125 (12.5)
Hydro	94 (9.4)
Landfill gas	90 (9.0)
Concentrating solar power	210 (21.0)

Table 3
REFIT phase II.
Source: Nersa (2009b, 1).

	ZAR c/kWh (EUR c/kWh)
Large scale grid connected PV (≥ 1 MW)	394 (39.4)
Biomass solid	118 (11.8)
Biogas	96 (9.6)
CSP tower with storage (6 h/day)	231 (23.1)
CSP, trough w/o storage	314 (31.4)

Nersa then invited and received a number of comments from stakeholders and the public in the form of submissions and public hearings. After deliberations in early 2009, the final decision on tariffs and contract length was taken in March 2009.

The initial phase of the adjusted REFIT included four technologies: wind, hydro, landfill gas and concentrating solar power (Table 2).

Six months after the REFIT launch Nersa included other renewable energy technologies, such as biomass and solar photovoltaics, in REFIT phase II. Furthermore, the tariffs for concentrating solar power (CSP) were adjusted (Table 3).

The tariffs are guaranteed for 20 years without degression. Each technology is eligible for a different tariff, since the costs differ in each case. The differentiated tariff system is to allow licensees to recover the full cost of the licensed activities plus a reasonable return. The REFIT design will be reviewed annually for the first five years and every three years thereafter to avoid a lock-in of inadequate tariffs. Adjusted tariffs will apply only to new projects. Investors can thus plan their investments on a long-term basis.

The changes to the REFIT design are substantial. While the initial design was greeted with scepticism, the new tariff rates were well received by investors and environmental organizations on their introduction. However, as long as only the monopolistic electricity supplier Eskom is allowed to buy the electricity produced from renewable energy sources, there is considerable uncertainty among renewable energy project developers. Reliability of profits as the most important incentive of the feed-in tariff scheme is lacking. Reliable profits have, however, been the basis of the scheme's success in other countries. Even though the REFIT is a promising approach, the current design of the electricity market is likely to impede the intended positive effect on private investment activity.

The effects of feed-in tariffs on the consumer price level of electricity are indirect and difficult to estimate. They depend on the tariff level, but also on the success it has in promoting investment in renewable energies. The higher the amount of "green" electricity fed into the grid, the more expensive the tariff system and the stronger the impact on electricity prices paid by the consumer. The German renewable energy law is estimated to have caused a price increase of about 12 per cent between 2002 and 2006 (BMU, 2007, 13). This moderate increase may be due to the already comparatively high price of electricity in Germany. The situation may differ in South Africa, depending on the actual success of the REFIT.

Before the introduction of the REFIT, there were earlier, but basically unsuccessful attempts to stimulate greenhouse gas mitigation projects in South Africa.

5.2.4. *Tax exemption for Clean Development Mechanism revenues*

The clean development mechanism (CDM) is one of the flexible mechanisms for which the Kyoto Protocol provides. It allows developers of low carbon projects in developing countries to generate carbon credits and sell them in the carbon market, thus obtaining additional financial resources. To promote clean investments, the South African government has introduced a tax exemption for CDM revenues. This measure is also aimed at improving South Africa's attractiveness for CDM projects. To date, the majority of CDM projects are situated in China and India (see Fig. 7).

Of the 4869 projects in the 2009 CDM pipeline, South Africa has managed to attract only 29 (UNEP Risoe Centre, 2009). The reasons for this rather poor performance are manifold, and tax exemption is unlikely to be the solution. Not only does the private sector lack the capacity to deal with the complex CDM regulations, but an extensive national approval procedure also has to be completed. For definitive approval by the Designated National Authority (DNA), projects must meet various social, economic and environmental requirements from a list of criteria for sustainable development. This approval procedure slows the project planning process and thus increases costs for project developers. Besides the sustainability criteria, an environmental impact assessment may be required for various project types.

However, the potential for CDM projects in South Africa is large. The high emissions from the use of coal mean there is potential for major reductions, and the levels of technological and economic development are comparatively high. Coupled with its abundant renewable energy resources, South Africa provides a favourable project development and investment climate. In 2006 PricewaterhouseCoopers estimated that at least ZAR 5.8 billion (about EUR 580 million) could be earned by 2012 from the sale of

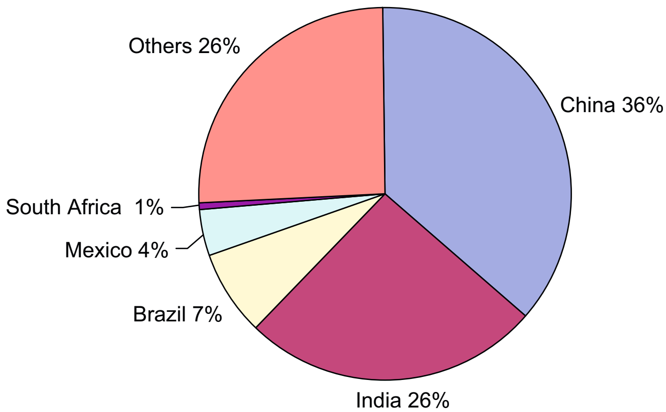

Fig. 7. Geographical distribution of CDM projects.
Source: UNEP Risoe Centre (2009).

CDM credits generated in South Africa (Fakir and Nicol, 2008, 25). In addition to renewable energy projects, the CDM potential of the energy sector lies in energy efficiency, cogeneration and energy generation from waste. The DNA is attempting to tackle the capacity problem by holding a series of CDM promotion and capacity-building workshops.

5.2.5. *Carbon tax vs. cap and trade*

While the aim of a feed-in tariff is to encourage investments in renewable energy, a carbon tax or cap and trade system seeks to discourage investments in fossil fuel technologies. Carbon taxes lead to a direct increase in the cost of producing electricity. If this increase is passed on to consumers, the price of electricity to households and to industry is affected. As a principal goal of South Africa's policy has long been universal access to electricity, with particular emphasis on the poor and rural areas, a policy trade-off may occur. Any suspicion of a conflict with such a high priority policy aim may make it difficult to "sell" a carbon tax to voters. This is especially true at times of financial and economic crisis, climate change being regarded by the public as a problem to be solved by the countries that are historically responsible. It may be politically more acceptable to introduce a levy on local air pollution, which will have a side-effect on greenhouse gas emissions, but focus on the benefits to local health. According to findings of a study by Spalding-Fecher and Matibe (2003), however, the external costs caused by air pollution in South Africa are considerably lower than those due to greenhouse gas emissions (see Table 4).

From an economic point of view, it is therefore more important to endogenize the external costs of greenhouse gas emissions than the costs of local air pollution. However, it is unclear whether a carbon tax would have the desired steering effect on emissions in South Africa. Eskom's de facto monopoly would simply allow it to pass the full costs onto the consumer, there being no incentive to change fuel use to cleaner energy. The only effect on emissions would then come from electricity savings on the demand side due to the higher price level (Table 4).

For that reason and because a tax directly increases the price of fossil fuel use, South African companies and the public oppose a carbon tax. Despite this, Environment Minister van Schalkwyk announced a ZAR 0.02/kWh levy on non-renewable electricity in 2008. The levy had already been included in the 2008 budget, and its introduction was scheduled for September 2008, but was eventually deferred until mid-2009. It was then included in the 31.3 per cent electricity price increase permitted by Nersa, which left Eskom with an average net price increase of 24.08 per cent.

Table 4
External costs of electricity generation from coal (1999 Rand c/kWh)[a].
Source: Spalding-Fecher and Matibe (2003, 727).

	Per unit of coal-fired power produced		
	Low	**Central**	**High**
Air pollution and health	0.5	0.7	0.9
Climate change	1.0	4.3	9.8
Total	1.5	5.0	10.7

[a] The estimate excludes the benefits of electrification from the avoidance of the indoor use of dangerous fuels.

The generation of revenues is one of the advantages of a carbon levy. These revenues may be used to cushion the impact of the levy on the poor. This can be done by reducing other taxes that affect the poor in particular, such as value-added tax on essential foodstuffs, or by subsidizing the electricity tariff for the poor (Winkler, 2009, 81). Even though South Africa's environmental tax revenues are not earmarked, the electricity price increase to poor households was restricted to 15 per cent by Nersa.

In spite of the opposition to higher electricity prices, the Long-Term Mitigation Scenario (LTMS) entails the introduction of fiscal measures to reduce carbon emissions. The mitigation option "Use the Market" proposed in the LTMS includes an escalating tax on greenhouse gas emissions, rising from ZAR 100 per tonne of CO_2eq in 2008 to ZAR 750 in 2040. This would translate into a tax of ZAR 0.102/kWh in 2008 and ZAR 0.765/kWh in 2040, assuming that 1.02 tonnes of CO_2 is emitted during the coal-based production of 1 MWh electricity. This demonstrates the gap between the mitigation scenarios, the most optimistic still not reaching the "required-by-science" emission limit, and political reality, where the introduction of a ZAR 0.02/kWh carbon levy is already proving to be problematic.

An alternative approach to reducing greenhouse gas emissions is the adoption of a cap-and-trade system. This system is already established in the European Union and may be adapted to the South African context. It is uncertain, however, whether the South African financial sector can handle the technicalities of a carbon trading system and, even more important, if there will be enough local participants to sustain it. With Eskom, Sasol and a few mining companies responsible for the bulk of South African emissions, the number of actors may be too small to ensure a functioning market.

6. Conclusions

South Africa is well endowed with renewable energy resources, especially solar energy. Tapping into this resource would help to meet both the emissions and the energy supply challenge. In addition, the deployment of renewable energy will reduce air pollution and so contribute to health improvements. Renewable energy technologies may also increase electricity access in remote areas since they are suitable for small-scale, off-grid solutions. By facilitating income generation and health care, they may help to tackle such social issues as rural poverty and the HIV/Aids epidemic.

However, the gap between renewable energy policy statements and actual implementation is wide. The introduction of the REFIT and the recent tariff rises – induced not by environmental concerns but by pure financial necessity – will not suffice to reduce South Africa's emissions by 30–40 per cent from the 2003 level by 2050 as envisaged by the Long-Term Mitigation Scenario (LTMS).

Even the best mitigation scenario is futile if it fails to induce actions on the ground. There is a serious need for a step-by-step implementation plan for the mitigation options outlined in the LTMS. However, the political capacity and the political will to translate this plan into actions are even more important. Steering an economy as coal based as South Africa's towards low-carbon development is an extremely complex task. Having focused on energy access for the past fifteen years, South Africa's policy makers now face a relatively unfamiliar challenge. Capacity building and sharing of experiences and best practices with other countries will support them in taking sound decisions. Political will, strongly influenced by power constellations within the country, is harder to tackle. As long as Eskom's predominance in the electricity sector remains untouched, independent power producers (IPPs) will find it challenging to enter the market and supply significant amounts of clean energy. However, the recent attempts by the Department of Energy to support IPPs may indicate a change of trend. The planned outsourcing of the Single Buyer's Office from Eskom to an independent entity is an important step. Additional elements of a supportive framework are underway, such as a standardised power purchase agreement and definite rules for the selection of renewable energy IPPs to be drafted by the energy regulator Nersa. The process gained impetus by the establishment of an inter-ministerial committee on energy in late 2009.

In addition to existing power constellations and the need to prevent future electricity shortages, South African policy makers are pressurised by the need to further expand electricity access. The trade-off between the need for a higher electricity price and the government's commitment to providing cheap electricity access, especially for the poor, certainly poses a major challenge. The REFIT, an established support measure to kick-start the renewable energy sector, might therefore face difficulties in achieving large-scale market penetration. The more renewable capacity is built, the higher the additional costs to consumers. As electricity prices are already rising steeply, any additional burden on consumers may not be accepted. The REFIT may thus be practicable for only small quantities of electricity generated; a political reality that may considerably reduce the effectiveness of the scheme.

Also, domestic technological capacity is a bottleneck. This problem persists at every educational level of the South African renewable energy sector. Any large-scale introduction of renewable energy technologies would require building innovative capacity in South Africa. This capacity is needed to install, operate, maintain and repair the technologies, but also to enable the development of country-specific solutions such as water-saving technologies for concentrating solar power (Edkins et al., 2009, 3).

To address these barriers to renewable energy deployment, South African policy makers may

- *Exchange experiences and learn from best practises in other countries*, such as Germany. While the German general circumstances differ from South Africa's, there are still valuable lessons to learn from Germany's experience with the feed-in law. One of the reasons for its success is guaranteed purchase and grid access for renewable energy: The electricity generated is to be purchased, transmitted and paid for by the grid system operators as a priority. This ensures reliable revenues of renewable energy producers and therewith investment certainty.
- *Further support independent power producers*. The missing elements are known, they have to be implemented into practise.
- *Involve the South African public in the drafting of policies*, e.g. the second Integrated Resource Plan. Transparency and public participation are crucial in decisions about long term investments such as energy infrastructure. In addition, other processes such as the REFIT drafting already benefited from the contributions of a committed and informed South African public.
- *Encourage Eskom to discover renewable energies as a future market*. As Eskom's single shareholder, the government should exert its influence towards the use of cleaner and non-finite sources of energy.
- *Put a high emphasis on energy efficiency measures* to reduce pressure on electricity supply. This will facilitate options for building new generation capacity other than the least cost solutions. Energy efficiency technologies can be advertised by information campaigns, but also by policies such as standards and regulations.
- *Ensure that new regulatory or policy measures are coherent with existing policies*. Various arms of the government must coordinate their activities to avoid conflicting approaches, such as a feed-in tariff and a competitive bidding process for electricity provision.
- *Take into account the possibilities arising from international cooperation*, e.g. in the context of the climate change negotiations. Many of the barriers to renewable energy deployment in South Africa, such as the additional financial burden on consumers caused by the REFIT, high investment costs for grid extension, the need for additional education and research and risk cover for early-stage technologies, can be overcome with external funding and technological assistance. While the negotiations in Copenhagen 2009 failed to provide fast-start funding, the outcome document ("Copenhagen Accord") at least provides the basis for further negotiations that will hopefully facilitate funding from 2011 onwards.

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